

Progress in a Study of Striations in the Dust Tail of Comet Hale-Bopp (C/1995 O1)

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We report preliminary results of a massive investigation of the striation patterns observed in the dust tail of comet Hale-Bopp in March and April 1997. Our findings are based on 16 wide-field photographs taken with Schmidt cameras on March 2–20, with six more, from March 31–April 8, still waiting for analysis. Altogether ~ 700 individual striae were examined on the 16 images, which were scanned and computer processed to enhance the morphology. About 5300 stria points, or some 7–8 points per stria per image on the average, were measured and their astrometric positions determined and subsequently converted to a Cartesian coordinate system, aligned with the comet's projected radius vector and centered on the nucleus.

The evolution of the striated tail has been studied using the Sekanina-Farrell fragmentation hypothesis (AJ 85, 1538, 1980), previously applied to other comets. This two-step model is characterized by the *time of release* from the nucleus of a parent object (or objects) whose motion is assumed to have been subjected to a constant repulsive *acceleration* β_p (presumably due to solar radiation pressure) until the *time of fragmentation*. At this point the parent breaks up into a cloud of grains with a wide range of radiation-pressure accelerations β_f . The model neglects the parent's initial velocity, any impulse that fragments may acquire upon the parent's breakup, and all forces that act only on electrostatically charged grains.

The success of the fragmentation model's application to Hale-Bopp exceeds all expectations. We have matched the expansion, through the dust tail, of a number of brighter striae over a period of two weeks, consistently with a mean (formal) residual of approximately $\pm 10^4$ km (equivalent to ~ 10 arcsec), at projected distances of up to ~ 20 million kilometers, or $\sim 6^\circ$, from the nucleus. The evolution of the products of ~ 140 events has been followed by linking the positions of striae on at least three (and as many as 14) images. The only reason for our not identifying the same striae on all 16 photographs was the fact that their residence time in the observed tail was limited to fewer than the 18 days spanned by our data sample.

The parent bodies appear to have been subjected to accelerations β_p that cluster around 0.55, 0.75, and 0.25 the solar attraction. The accelerations of fragments in the striae are generally confined to $1 < \beta_f < 3$ in the same units. The 140 stria generating events took place during the first 60 days of 1997 (between 1.75 and 1.09 AU from the Sun preperihelion), with the breakup of the parent following its release from 5 to some 50 days later. The fragmentation lifetime depends on both β_p and the comet's heliocentric distance at the time of release.

An investigation of possible periodicities in the recurring release events is in progress. Whereas it has been known that grains that populate striae are predominantly submicron-sized absorbing, presumably carbon-rich, particles (and their clumps), the nature of the parents was in the past unclear. Since the evolution of striae could never before be followed for longer than a few days, only soft constraints could be set on the initial velocity of the parents. With the motions of striae now fitted over much longer times, it is clear that the release of the parents is accomplished with an exceptionally low velocity, as otherwise the effect could not be ignored. Thus, our results suggest that the objects that feed striae are massive (perhaps up to tens of meters across) but extremely porous (because of the high β_p values) and fragile, of fairy-castle type and presumably very irregular in shape, with one parent per stria. An upper limit to a parent's initial velocity is estimated at only several meters per second, a value that can be compared with the nuclear rotational velocity of large, fairly rapidly spinning comets.